CLAIMS

1. A laser apparatus for creating visible surface deformations on the surface of a workpiece such as a multi-layered workpiece including an upper carbon layer, at least one intermediate metallic layer, and a lower substrate, comprising:

(a) a laser generator for generating an output laser beam;

(b) a beam conditioner responsive to said output laser beam and operative to generate a conditioned laser beam, said beam conditioner including (i) a beam expander responsive to said output laser beam and operative to generate an expanded laser beam and (ii) a variable beam attenuator responsive to said expanded laser beam and operative to generate a conditioned marking beam;

(c) a beam steerer for directing said marking beam to a surface of a workpiece; and

(d) a materials handler for positioning said workpiece in the path of said marking beam.

2 A laser apparatus as recited in Claim 1 wherein said variable beam attenuator includes a first optical plate responsive to said expanded laser beam and operative to generate a conditioned laser beam; and a beamsplitter responsive to said conditioned laser beam and operative to split said conditioned laser beam into a plurality of beams including said marking beam.

3. A laser apparatus as recited in Claim 2 wherein said first optical plate is rotatable along an axis parallel to that of said laser beam and operative to vary the fluence of said marking beam striking said ~~workpiece~~ hard disk.

4. A laser apparatus as recited in Claim 2 wherein said first optical plate is a half-wave plate.

5. A laser apparatus as recited in Claim 1 wherein further comprising a beam sampler and a detector, said beam sampler being positioned in the path of said marking beam and capable of passing a sample of said marking beam to said detector,

said detector being capable of receiving said sample and generating a signal responsive to the fluence of said marking beam.

6. A laser apparatus as recited in Claim 1 wherein said variable beam attenuator includes a beamsplitter, and wherein said apparatus further comprises anoptical isolator for optically isolating the laser generator from any reflection of said marking beam to said laser generator, said optical isolator including a second optical plate positioned in the path of said marking beam, whereby the polarization plane of any reflection of the marking beam is rotated such that the reflection exits the beamsplitter in a direction away from said laser beam generator.

7. A laser apparatus as recited in Claim 6 wherein said second optical plate is a quarter-wave plate.

8. A laser apparatus as recited in Claim 1 wherein said laser generator includes a Q-switched diode-pumped laser.

9. A laser apparatus as recited in Claim 1 further comprising a processor capable of receiving one or more signals responsive to one or more of variables from the group consisting of the status of said laser generator, the pattern of marks to be placed on said ~~workpiece~~ hard disk, the direction of said selected beam leaving said beam steerer, and the position of the ~~workpiece~~ hard disk relative to the beam steerer, said processor being capable of generating one or more signals affecting the status of said laser generator, the desired pattern of marks to be made on the surface of said ~~workpiece~~ hard disk, the direction of the beam leaving the beam steerer, or the position of the ~~workpiece~~ hard disk to be marked.

10. A laser apparatus as recited in Claim 1 wherein said laser generator is operated in a pre-lasing mode.

11. A laser apparatus as recited in Claim 1 wherein said selected beam is scanned across a portion of the surface of said workpiece to form deformations therein in a predetermined pattern.

12. A laser apparatus as recited in Claim 11 wherein the resolution of said pattern is determined by varying the size of the beam from said beam conditioner.

13. A laser apparatus as recited in Claim 11 wherein said laser beam is in pulses, and the contrast of said pattern is varied by changing one or more of the group consisting of pulse energy, pulse frequency and laser beam scanning speed.

14. A method for creating a surface deformation on the surface of a workpiece such as a multi-layered workpiece including a substrate, a first layer placed over said substrate and having a first melting point, one or more additional layers placed over said first layer and having melting points higher than said first melting point, and a protective layer placed over said additional layers, said method comprising the steps of:

(a) generating a laser beam;

(b) expanding said laser beam to a predetermined diameter;

(c) attenuating the expanded beam to a level suitable for creating said surface deformation.

(d) passing the attenuated beam to a beam steerer to produce an output marking beam;

(e) positioning said workpiece in the path of said marking beam;

(f) creating one or more deformations on a surface of said workpiece by scanning said marking beam over said surface.

15. A method as recited in Claim 14 wherein said expanded beam is attenuated by passing said expanded beam through a first optical plate and passing the output from said first optical plate through an optical device responsive to said first optical plate, thus producing said attenuated beam.

16. A method as recited in Claim 15 wherein said first optical plate is rotatable along an axis parallel to that of said laser beam and operative to attenuate said marking beam.

17. A method as recited in Claim 15 wherein said optical device is a beamsplitter operative to produce a plurality of beams, including said attenuated beam.

18. A method as recited in Claim 15 further comprising optically isolating said laser generator from said workpiece by positioning a second optical plate in the path of said attenuated beam.

19. A method as recited in Claim 18 wherein said first optical plate is a half-wave plate and said second optical plate is a quarter-wave plate.

20. A method as recited in Claim 14 further comprising taking a sample of said attenuated beam, determining the fluence of said attenuated beam from said sample, and generating a signal responsive to said fluence.

21. A method as recited in Claim 14 further comprising using a processor to obtain signals responsive to the status of one or more of the group consisting of laser beam on/off status, position of the beam steerer, and position of the workpiece, and to generate one or more signals to control one or more of the group consisting of the frequency, fluence, spot size, on/off status and scanning speed of said marking beam, and movement of said marking beam relative to said workpiece.

22. A method as recited in Claim 21 further comprising forming said deformations in a predetermined pattern on a portion of said surface of said workpiece by inputting a predetermined pattern into said processor and using the processor to control scanning said marking beam over said portion.

23. A method as recited in Claim 22 further comprising forming said deformation by melting said first layer while substantially maintaining the integrity of said protective layer.

24. A method as recited in Claim 14 further comprising forming a pattern of deformations on a portion of said surface by controlling one or more of the group consisting of the frequency, fluence, spot size, and on/off of said marking beam, and

the scanning speed and relative position of said marking beam with respect to the surface of said workpiece.

25. A method as recited in Claim 14 wherein said laser beam is generated by a diode-pumped laser.

26. A method as recited in Claim 25 wherein said laser is operated in a pre-lasing mode.

27. A method as recited in Claim 25 wherein said laser beam is pulsed, the beam pulses being formed by a Q-switch operating said laser.

28. A workpiece having a surface marked by selectively located deformations and including a substrate, a first layer adjacent to said substrate and having a first melting point, one or more additional layers, at least one of which is adjacent to said first layer, said additional layers having melting points substantially above said first melting point, and an outer protective layer adjacent to the outermost of said additional layers, the surface of said workpiece having laser-induced visible surface deformations and a substantially intact protective layer over said deformations, said deformations being formed by a method which comprises the steps of

((a) generating a laser beam;

(b) expanding said laser beam to a predetermined diameter;

(c) attenuating the expanded beam to a level suitable for creating said surface deformation.

(d) passing the attenuated beam to a beam steerer to produce an output marking beam;

(e) positioning said workpiece in the path of said marking beam;

(f) creating one or more deformations on a surface of said workpiece by scanning said marking beam over said surface.

29. A workpiece as recited in Claim 28 wherein said expanded beam is attenuated by passing said expanded beam through a first optical plate and passing the output

from said first optical plate through an optical device responsive to said first optical plate, thus producing said attenuated beam.

30. A workpiece as recited in Claim 29 wherein said first optical plate is rotatable along an axis parallel to that of said laser beam and operative to attenuatesaid marking beam.

31. A workpiece as recited in Claim 29 wherein said optical device is a beamsplitter operative to produce a plurality of beams, including said attenuated beam.

32 A workpiece as recited in Claim 28 wherein said laser generator is optically isolated from said workpiece by positioning a second optical plate in the path of said attenuated beam.

33. A workpiece as recited in Claim 32 wherein said first optical plate is a half-wave plate and said second optical plate is a quarter-wave plate.

34. A workpiece as recited in Claim 28 further comprising maintaining said workpiece at a predetermined location with respect to said beam steerer during said scanning.

35. A workpiece as recited in Claim 28 wherein said marking beam is pulsed and has a fluence of about 0.8 Joule/square centimeter, a wavelength of 1064 nanometer, and a pulse duration of about 50 nanoseconds.

36. A workpiece as recited in Claim 28 wherein said laser beam is generated by a diode - pumped laser.

37. A workpiece as recited in Claim 28 wherein said workpiece is a magnetic media hard disk, said first layer including nickel-phosphorous, said additional layers including a chromium layer and a magnetic layer, and said protective layer including carbon, said workpiece also containing a surface lubricant adjacent to said protective layer.

38. A workpiece as recited in Claim 37 wherein said disk is a clean finished disk.

39. A workpiece as recited in Claim 28 wherein said deformation is produced by laser-induced melting and subsequent resolidification of said first layer while maintaining the integrity of said carbon layer.

40. In a method for making a workpiece having visible surface marking, said workpiece having multiple layers including a substrate, a first layer with a first melting point adjacent to said substrate, one or more additional layers at least one of which is adjacent to said first layer, said additional layers having melting points substantially above said first melting point, and a protective layer adjacent to the outermost of said additional layers, the improvement comprising: creating said surface marking by melting said first layer while leaving said protective layer substantially intact by using a laser beam having a wavelength within the range of about 400 to about 10,000 nanometers, a pulse duration within the range of about 30 to about 120 nanoseconds, a pulse frequency from about 1 to about 100 kilohertz, a laser fluence from about 0.5 to about 1.5 Joules/square centimeter, and a laser spot size diameter from about 10 to about 30 micrometers.

41. A method for making a workpiece as recited in Claim 40 wherein said laser beam has a fluence of about 0.8 Joule/square centimeter, a wavelength of 1064 nanometers, and a pulse duration of about 50 nanoseconds.

42. A workpiece having visible surface marking and multiple layers including a substrate, a first layer adjacent to said substrate having a first melting point, one or more additional layers at least one of which is adjacent to said first layer and with melting points substantially above said first melting point, and a protective layer adjacent to the outermost of said additional layers, said markings being formed by melting said first layer while leaving said protective layer substantially intact by using a laser beam having a wavelength within the range of about 400 to about 10,000 nanometers, a pulse duration within the range of about 30 to about 120 nanoseconds, a pulse frequency from about 1 to about 100 kilohertz, a laser fluence from about 0.5 to

about 1.5 Joules/square centimeter, and a laser spot size diameter from about 10 to about 30 micrometers.

43. The workpiece as recited in Claim 42 wherein said laser beam has a fluence of about 0.8 Joule/square centimeter, a wavelength of 1064 nanometers, and a pulse duration of about 50 nanoseconds.

44. The workpiece as recited in Claim 42 wherein said markings have the general ripple structure shown in Fig. 9 herein, and representative data profile plots as shown in Figures 9a, 9b, and ~~9c herein~~.

45. The workpiece as recited in Claim 42 wherein said markings have the general ripple structure shown in Fig. 6 herein.